PROJECT **facts**

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Gas Exploration, Production, and Storage

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GSAM
THE GAS SYSTEMS ANALYSIS MODEL
Measuring Natural Gas R&D Value

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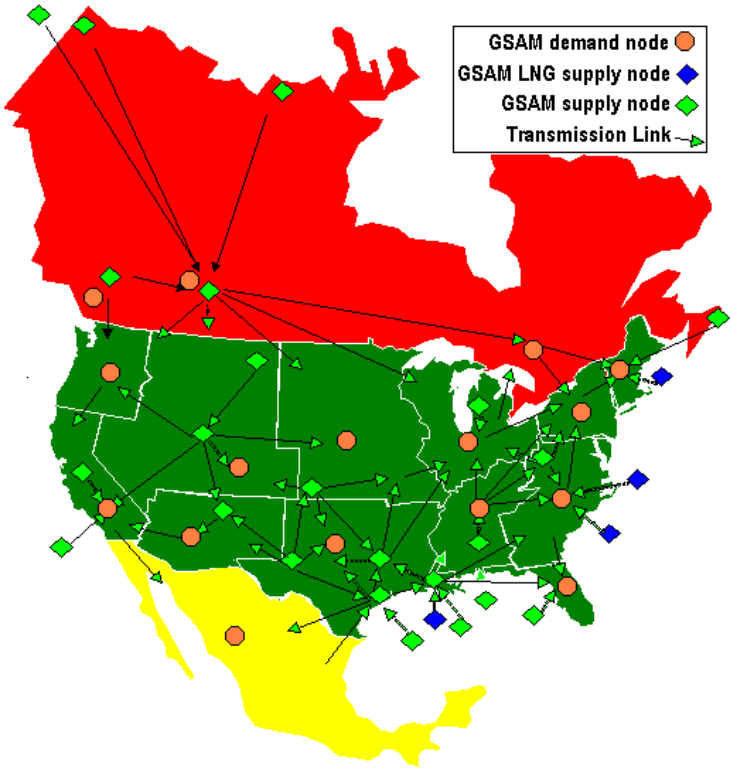
Overview

The Department of Energy (DOE) is charged with ensuring the nation's energy security, economic health, and environmental protection by promoting the most efficient and responsible utilization of the nation's energy resources. To support this goal, DOE planners in the Strategic Center for Natural Gas at the National Energy Technology Laboratory conduct detailed analyses of alternative R&D and policy scenarios using the Gas Systems Analysis Model (GSAM). GSAM's complex suite of resource databases, market characterizations, and computer programs allows decision-makers to assess and compare the potential impact of alternative R&D/Policy scenarios on future national gas supply, price, and use, as they craft the nation's natural gas R&D portfolio.



GSAM estimates the potential impact of alternative technology/policy scenarios on the production and use of natural gas in North America.

Model Capabilities

The primary use of GSAM is to provide insight into the role of technology and policy in impacting future natural gas use. Specifically, GSAM can assess the impact of the following:

- Technological advances that alter the productive capacity of natural gas reservoirs.
- Technological advances that alter the costs and risks of finding and producing natural gas.
- Changes in industry's capacity to explore for and produce natural gas.
- Changes in regulation, taxation, and royalty structures that impact the natural gas industry.
- Changes in the rate at which natural gas technologies are utilized in the marketplace.
- Changes in the size and efficiency of the national gas storage system.
- Changes in the capacity, cost, and efficiency of the overall national gas pipeline system.
- Alternative scenarios for the future markets for natural gas.

What Sets GSAM Apart?

GSAM has been specifically designed to model natural-gas supply technologies. Whereas other models are limited to broadly defined "high" and "low" technology cases, GSAM provides means to evaluate the potential impacts of specific technologies and policy actions. There are four main aspects of the model that allow this to occur.

- **GSAM is based on estimates of remaining gas-in-place.** GSAM is unique in that it uses a resource characterization that goes beyond current estimates of what is "technically recoverable". By including large volumes of gas currently viewed as uneconomical and unrecoverable (a category that once included both tight gas and coalbed methane), the model can help us determine what paradigm-altering technologies will be needed to allow the next dramatic expansion in the nation's natural-gas resource base.

- **GSAM uses production type curves to estimate future supply:** As compared to complex and time-intensive reservoir simulation or overly-simplistic decline curve projections, GSAM's type-curve approach provides a superior means to quickly and scientifically estimate how technology advances will impact future production rates on large volumes of reservoirs.

- **GSAM contains detailed reservoir-specific characterizations:** Instead of idealized abstractions that reflect general reservoir behavior, GSAM's resource database contains real field-derived data for more than 5,000 existing reservoirs that represent more than 90 percent of the natural gas production in the United States and Canada. In addition, more than 10,000 as-yet undiscovered gas accumulations are characterized using the latest estimates from the United States Geological Survey. This extraordinary level of detail allows GSAM estimates to be highly responsive to the natural geologic variation present within the nation's natural- gas resource pool.

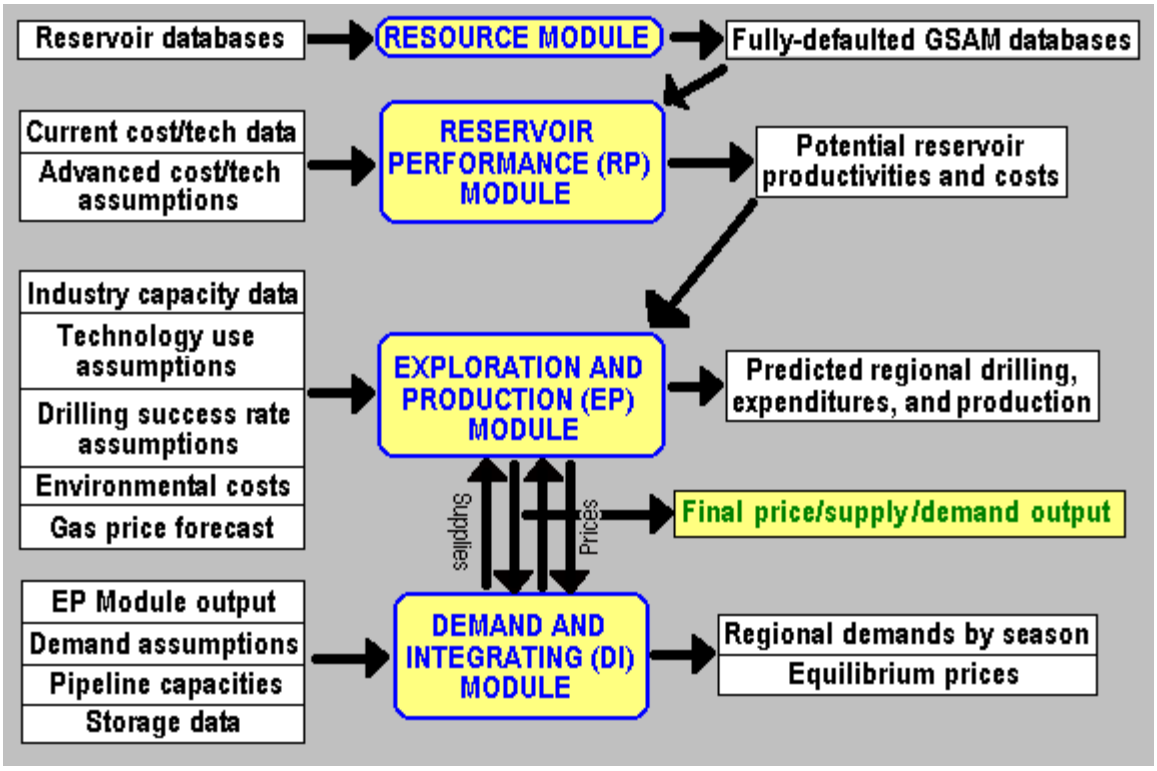
- **GSAM is a fully integrated model of the entire North American gas system:** GSAM incorporates a variety of market constraints including: (1) measures of industry supply capacity, (2) expected future prices for gas, (3) the rates at which technologies can be expected to penetrate the market, (4) a representation of natural gas transmission capacity, (5)the national gas storage system, and (6) expectations for demand in various end-use markets for gas. These constraints allow the model to determine if the additional supplies enabled by advanced exploration and production technologies can be realistically produced and delivered where and when needed.

How GSAM works

GSAM works through sequential modules to estimate the impact a hypothetical change in some aspect of the natural gas system might have on the operation of the system as a whole. Greatly simplified, GSAM's upstream modules estimate the potential productivity of individual reservoirs for two (current and advanced) cost/technology cases. The downstream modules then evaluate which reservoirs will be produced in each year, and under which technology/cost case, given market constraints, prices, and assumed industry utilization rates.

- **Upstream Modules:** The Resource and Reservoir Performance Modules of GSAM answer the question, "How could a change in technology and/or costs affect production potential of the nation's gas reservoirs?" These modules accomplish this by running each of 15,000+ resource segments through simple, 3-second simulations based on production type curves. Yearly gas volumes, costs, and an estimate of the minimum acceptable supply price required to make the production economic, are output.

- **Downstream Modules:** GSAM's downstream modules can be run in two separate modes to determine how the upstream module's estimates of production potential will be realized. One mode uses a standard gas-price forecast such as provided by the Energy Information Administration's Annual Energy Outlook (AEO). GSAM's Exploration and Production Module then selects which reservoirs will be produced, based primarily on the availability of advanced technology and expected industry drilling capacity. Alternatively, the user can allow GSAM's Demand and Integrating Modules to determine if markets exist for these volumes, and if the gas can be economically delivered to those markets, by invoking characterizations of the pipeline network, gas storage system, and expected future demand. In this mode, GSAM's internal linear solver works to calculate a balance of supply and demand by region and season, and provides its own estimate of likely future gas prices.



GSAM consists of a complex suite of state-of-the-art computer modules and databases.

GSAM
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Outputs

Some of the outputs of a full GSAM run include:

- Natural-gas production by region, resource type, geologic play, and location on federal or private lands.
- Costs incurred in producing the gas.
- Royalties and taxes paid.
- Estimates of industry activity, including wells drilled, success rates, pipeline utilization, and more.
- Natural-gas prices at the wellhead and end user.
- Natural-gas consumption by region, season, and sector (industrial, commercial, residential, and electric generation).

How DOE uses GSAM

Development of GSAM began in 1991. Peer reviews in 1994 and 1997 guided enhancements to the model. Although several key components are still in development, including integration with the DOE oil-system model, TORIS, GSAM has already contributed through the following applications:

- **Gas R&D Program Metrics**—DOE periodically runs GSAM analyses to estimate the future impact of its ongoing R&D programs. A calibrated base case (the most likely future scenario) is compared to alternative cases that do not include the expected R&D outcomes of various program elements. The difference between these cases is an estimate of the realized impact of that R&D. These impacts are then analyzed with respect to timing, program costs, and conformance to program mission, to determine program benefit. Metrics analyses using GSAM were conducted in 1995, 1999, and 2001.

- **Gas R&D Program Planning**—DOE also runs GSAM to test the potential impact of various contemplated activities. In this mode, a large number of possible impacts are run iteratively in an attempt to identify those aspects of the national gas system that may provide the most leverage in achieving the program's goal of increased supply at reasonable prices. The insight from such analyses supports the setting of program goals and prioritizing program portfolios.

- **Gas Policy Analyses**—GSAM is used by DOE to investigate the impacts of various policy initiatives. Examples of policy analyses supported by GSAM include studies to estimate the economic impact of changes in taxation and royalty on (1) low-volume "stripper" wells and other marginal, high-cost resources; (2) land-use regulation that restricts access to vast gas resources, both offshore and in key western basins, and; (3) environmental regulations that add incremental costs to gas production.